# Lithography and patterning of molecules and nanoparticles using Nanotubes

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“Lithography and patterning of molecules and nanoparticles using Nanotubes”. In this research project, we propose a novel method for the deposition and patterning of chemical and biochemical molecules and nanoparticles onto flat surfaces at the submicron level. Conical nanotube arrays are embedded in an impervious glass matrix, which are used as “nanopens” for the deposition of biomolecules on flat surfaces. The molecules will be transported through electrophoretic (EPF) and/or electroosmotic (EOF) mechanisms onto a surface through the use of appropriate sign and magnitude of applied potential between molecules in the nanotubes and surface. A schematic diagram of this system is shown in Figure 1. Each nanotube (smaller pore diameter: 20 nm-500 nm; large diameter: 1 μm-50 μm; length: 30-90 μm) will be individually electric addressable to an external power source. The distance between the nanotubes and surface will be kept small (<200 nm) to minimize the diffusion of molecules in a lateral direction once they leave the nanotube tips but before they adsorbed onto the surface. The main advantages of the proposed system over existing technologies includes its comparative speed, inexpensive process of fabrication, and controlled active and parallel deposition of molecules and nanoparticles at the submicron level on surfaces.

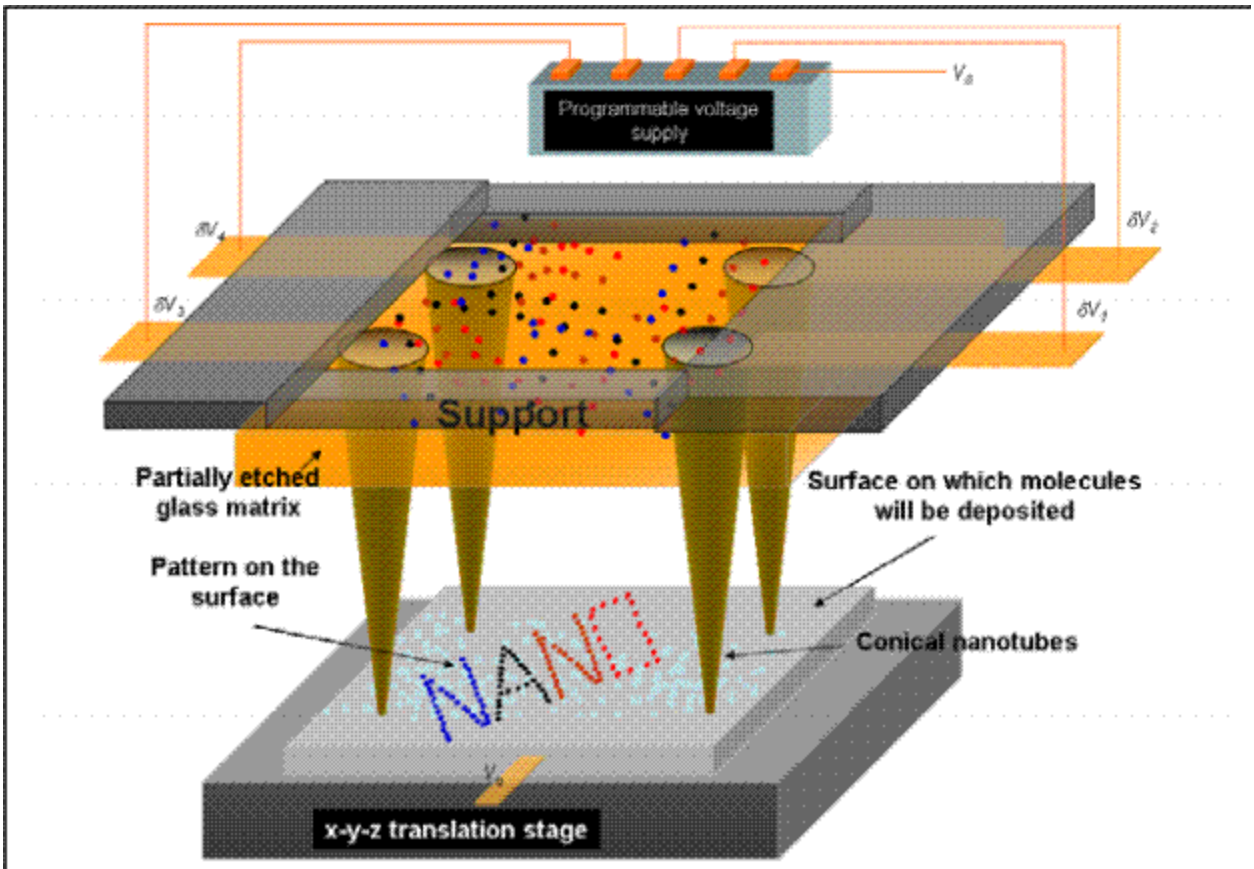


**Figure 1. Four individually addressable conical nanotubes are embedded in a glass chip and are connected to a programmable voltage supply. Through electrophoresis and/or electroosmotic mechanisms, the molecules/nanoparticles can be transported onto a surface. The distance between the nanotubes and a substrate on which the molecules will be deposited is controlled by a piezoelectric translator. In contrast to passive lithography such as DPN, four different molecules may be deposited without reloading the system with molecules one at a time.**

Ultimately, proposed device will find potential applications in a wide range of fields including materials sciences, bioanalytical chemistry, medicine, drug discovery, and biochemistry. Some applications of the proposed research includes probing molecular interactions for catalysis; protein-protein and protein-drug interactions; chemical- and biological-sensors; applications in the areas such as light-emitting and imaging devices; and alternative energy source devices etc.

REU students working of this project will have a unique opportunity to work in a highly interdisciplinary and collaborative research in nanotechnology and materials science. They will fabricate and characterize nanotubes-containing chips using the state-of-the-art analytical techniques such as scanning and transmission electron microscopies. The students will learn and apply fundamental physical principles such as EPF and EOF for the molecular patterns on surfaces. The characterization of the

patterns will be performed using fluorescence and atomic force microscopies. The students will also interact and collaborate with other members of our group. The research experience gained by the students would help them expose and contribute to solve complex scientific and technological problems in nanotechnology and analytical and physical chemistries.

1. References: (1) Owen Y. Loh, Andrea M. Ho, Jee E. Rim, Punit Kohli, Neelesh A. Patankar, and Horacio D. Espinosa “Electric Field-Induced Direct Delivery of Proteins by a Nanofountain Probe” PNAS 2008, 105, 16438-16443. (2) Pradeep, R.R.; Wolff, Justin; Zhou, Chuanhong; Kinsel, Mary; Trautmann, Christina; Aouadi, Samir; Kohli, Punit “Two-dimensional pore gradient in tracked glass” Pradeep, R.R.; Wolff, Justin; Zhou, Chuanhong; Kinsel,Mary; Trautmann, Christina; Aouadi, Samir; Kohli, Punit “Two-dimensional pore gradient in tracked glass” Journal of Materials Chemistry J. Mater. Chem. 2009, 19, 8142–8149. (3) Zakeri, R.; Pradeep, R. R.; Trautmann, C.; Kohli, P. JACS (in preparation).